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ABSTRACT

Most Aboriginal people in Australia lack the background qualifications to enter higher education courses in science and mathematics. In 1984, the Western Australian Institute of Technology (WAIT) (now Curtin University of Technology) developed a project which created and evaluated bridging courses for Aboriginal people seeking to gain access into mathematics and science programs at the higher education level. This paper describes the WAIT project, which jointly involved WAIT's Centre for Aboriginal Studies and Science and Mathematics Education Centre. Explanations are provided of the project's: (1) four phase approach; (2) model of the bridging program; (3) course structure; (4) instructional materials; (5) evaluation; (6) current status; and (7) future directions. (ML)

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BRIDGING PROGRAMS FOR ABORIGINES WISHING TO STUDY SCIENCE AND MATHEMATICS IN HIGHER EDUCATION

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BACKGROUND

Currently in Australia, only a handful of Aboriginal people ever have completed higher education qualification in science-related or mathematics-related fields and most Aborigines lack the background qualifications necessary to enter higher education courses in science and mathematics. Consequently, during the latter part of 1984, a proposal from the Western Australian Institute of Technology (WAIT) (now Curtin University of Technology) was submitted to the Commonwealth Tertiary Education Commission (a national body with responsibility for coordinating higher education in Australia) requesting funding for a project designed to create and evaluate bridging courses for Aboriginal people seeking to gain access into mathematics and science programs at the higher education level. The Commission administers an Equity Program aimed at encouraging approaches to improve the participation of disadvantaged groups, including Aborigines, in higher education. One million dollars was made available in 1985 for the Equity Program and 15 proposals (including the WAIT submission) were successful in obtaining the funding sought. This paper describes the WAIT project, which jointly involved WAIT's Centre for Aboriginal Studies and Science and Mathematics Education Centre.

ABORIGINES AND POST-SECONDARY EDUCATION

The Australian Government's concern over the plight of the Aborigine has been evident for around a decade and was prompted by the knowledge that Aboriginal people are not well served by the Australian education system. In its report Aborigines and Tertiary Education, the National Aboriginal Education Committee (NAEC, 1984) demonstrated clearly that, at all levels from pre-school to higher education, the structure and processess of education generally are inappropriate for Aborigines and give little recognition to their special needs and aspirations. The Commonwealth Tertiary Education Commission's 1983 guidelines identified Aborigines as the group in Australian society "most starkly under represented across courses, institutions and sectors within tertiary education ... they have been deprived of much that their society offers and our society has been deprived of the contribution they could make".

A basic problem in increasing Aboriginal participation in tertiary education has been the low retention and achievement rates of Aboriginal children in secondary schools. Fewer than 10% of Aborigines who commence secondary school remain there to complete their final year compared with the national average retention rate of 35%. The NAEC report reveals that there were 454 Aborigines in Year 12 in 1982; there would have been about 1600 if the retention rates for Aborigines had been the same as for the general population.

In view of the relative lack of Grade 12 graduates, there would appear to be much that can be done within the higher education sector to ensure greater participation and success by Aborigines at this level. A basic reason for the inadequacy of schooling for Aboriginal children is the lack of Aboriginal teachers. More significantly, there is a large pool of mature-age Aboriginal people who haven't had the opportunity to obtain more than minimal secondary schooling, but who are capable of completing higher education award courses. These mature-age people have comprised a high proportion of Aboriginal higher education students and will continue to do so. This observation about the prevalence of mature-age Aborigines has many implications for planning, especially in relation to the structure of

programs (e.g., bridging courses, off-campus programs) and support provisions (e.g., child care, accommodation, student allowances, study leave from employment).

The NAEC report identified teaching as the major field in which there is a particular need for professionally qualified Aborigines. Several other discipline areas have been nominated by Aborigines as having a significant impact on them and in which special efforts should be made to encourage their participation; these include mathematics/economics, law, medicine, science, nursing, management, social work, politics, anthropology, linguistics and communications to mention but a few.

The Western Australian Institute of Technology seemed well placed to respond to these shortcomings in higher education study opportunities for Aboriginal people because it offers a wide range of undergraduate courses, including many in mathematics and science. WAIT already had a 12-month bridging course into the Social Science area which had run since 1976 and which enrolled over 300 students in the program since its inception. As will be indicated later, the experience gained in this course, its format and its structure provided a framework within which the bridging program described in this paper was designed. Expertise available through other resources at WAIT, such as the Faculty of Education, also contributed to the total support for the proposed program.

OVERVIEW OF BRIDGING PROGRAM PROJECT

The objectives of the project were to design and implement teaching programs (bridging courses) for Aboriginal people so as to assist them to take their places in higher education mathematics and science courses. This goal was to be achieved by:

- identifying the particular learning styles, teaching strategies and cognitive processing approaches appropriate for Aboriginal people studying mathematics and chemistry;

- developing bridging courses for Aborigines who wish to follow careers in mathematics and science;

- enriching the participants' backgrounds in mathematics and chemistry; and

- evaluating the program in order to enhance its impact and quality.

The project was conducted in four phases:

(a) The Preparatory Phase

During this period, the particular learning styles, cognitive processing approaches and teaching strategies appropriate for use with Aboriginal people studying mathematics and science were documented in order to constitute the knowledge base for the study. This phase commenced with a definition of criteria and parameters within which bridging course units were developed. It involved a literature search, a review of current bridging course offerings, the formation and support of a Steering Committee made up of experts in the Aboriginal culture and examination of other related minority cultures (e.g., the American Negro, Alaskan Natives and the North American Indian) in order to ensure that the criteria of the project were relevant and appropriate and that all available resources were assembled to support it.

A summary of the findings of this preliminary work is contained in three reports: Ethnomathematics and the Australian Aborigine (Malone et al., 1985a); Post-Secondary Education in Mathematics for the Australian Aborigine (Malone et al., 1985b); and Enhancing Access to Tertiary Science and Mathematics Among Aborigines (Taylor et al., 1986).

(b) The Developmental Phase

During this phase, a series of bridging course units for Aboriginal people who wish to follow careers in mathematics and science areas were developed. These units involved provision for enriching the participants' background in mathematics and chemistry. A curriculum planner/course designer ascertained appropriate teaching strategies, taking into account cross-cultural aspects required to teach Aborigines.

(c) The Pilot Study

During this phase, the bridging course materials were tried out with Aborigines at WAIT with a view to ensuring that they could be readily implemented and that they were of use to students both at WAIT and at other higher education institutions. This segment of the study involved teaching the new materials, obtaining information from Aboriginal students and staff and collecting statistics as the teaching program continued. The pilot study was reviewed and necessary modifications carried out in order to improve the program for implementation during 1986.

(d) The Evaluation Phase

An examination of the program, including further field testing of the bridging course materials, was conducted. Formative evaluation of the program was carried out in conjunction with the pilot testing.

The project commenced in February 1985 and concluded at the end of 1986. The bridging program is now fully operational at WAIT and operates alongside the one-year bridging program into the social sciences.

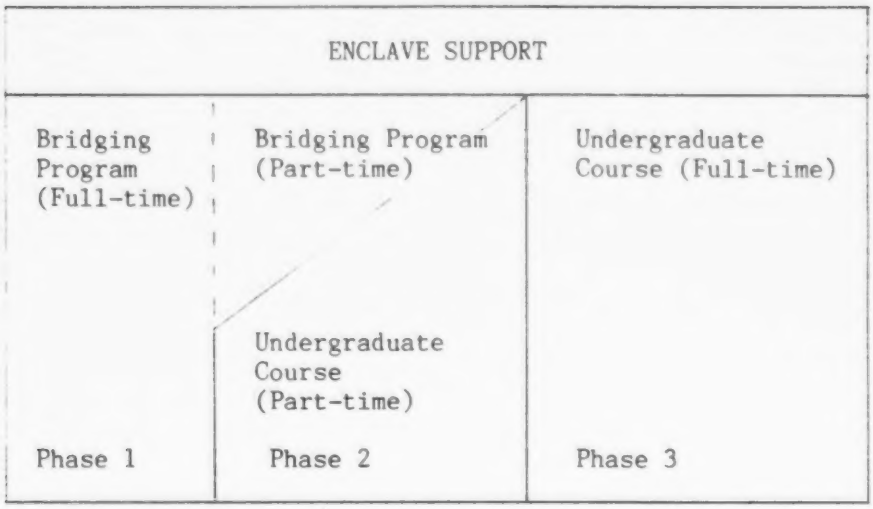
MODEL OF THE BRIDGING PROGRAM

The Centre for Aboriginal Studies' original bridging program is fundamentally an introduction to basic units which provide a background to the courses in which these students will become engaged. In addition, there is intensive teaching of study skills (speed-reading, note-taking, listening skills, study methods) and attention is given to the media, current affairs, Aboriginal studies and community survival skills (consumer protection, insurance). The Centre has an 'enclave support system' which provides a place for Aboriginal student interaction, counselling and tutorial assistance.

The mathematics and science bridging courses utilized this existing framework by incorporating it into the overall model which bridges Aboriginal students enrolling for the first time at WAIT into undergraduate mathematics and science courses. The model appears in Figure 1.

Figure 1

The Mathematics and Science Bridging Program



WAIT's academic year is divided into two semesters, each of 17 weeks duration. During the first semester (Phase one) the full-time bridging program prepares students to commence an undergraduate course in second semester. The bridging program has been designed around the special learning needs of Aboriginal students who elect to study Mathematics and/or Chemistry as their major subject (depending on their expressed career interests). Other 'core' subjects include Study Skills and Assertiveness Training. Aboriginal Studies is a compulsory subject. These core units are drawn from the Centre for Aboriginal Studies course and conducted by Centre staff.

Depending on the progress of individual students during first semester, first-year undergraduate units could commence in second semester. However, not all students are ready for full-time degree studies so quickly. Those requiring further preparation and special support continue with the bridging program and commence the undergraduate course on a part-time basis (Phase two). When fully prepared, these students continue with their undergraduate course as full-time students (Phase three). The bridging program is phased out for each student according to individual progress, which is closely monitored and evaluated each semester.

Throughout the duration of their studies, students have access to the enclave support system which provides them with counselling and tutorial assistance.

COURSE STRUCTURE

The Chemistry program comprises 12 units of study which must be completed by all students. The Mathematics program, on the other hand, provides a 'menu' of 17 units from which students select a subset according to the requirements of the undergraduate course for which they wish to qualify. This enables the bridging course to be tailored to the needs of the

individual student. Both programs provide students with the opportunity of qualifying at a standard equivalent to the Tertiary Entrance Examination conducted in Western Australia (which qualifies Grade 12 students for entry into higher education).

For each unit there is a specially designed set of students' notes based on the learning management plan shown in Figure 2. At the commencement of a unit, the student takes a diagnostic pretest to determine an appropriate 'entry point' into the unit. The ungraded results of the pretest are recorded in a special personal study plan. The student then can be directed to a review program if the pretest results indicate a need for further instruction in specific prerequisite topics. More able students proceed directly to the 'core' study programs, of which there could be two or three per unit. Each study program comprises: a list of learning objectives to be mastered; instructional activities referenced to commercially available text and computer-based educational programs (where available); and 'study tips' on memorization, important concepts and revision exercises. On completion of the study programs, students take a supervised 'mastery' test to determine their readiness to proceed to the next unit of study. If 'mastery' is not achieved, the tutor is alerted to the existence of an individual student's learning difficulties. The tutor's role is to diagnose the nature and causes of the learning difficulties and to ensure that the student undertakes further 'remedial' instruction prior to attempting a subsequent mastery test.

A separate set of specially designed tutors' notes is available for each unit. These notes provide tutors with the pretest and mastery test and their solutions, as well as an overview of the unit which cross-references every test item with its corresponding topic in the study program (although only the pretest appears in the students' notes).

Each of the programs is structured in such a way that the major traditional role of the tutor as primary source of instruction is considerably diminished. Assisting students to develop self-management skills and providing personal support through a knowledge and understanding of students' individual daily circumstances are among the major educational principles of the program. These principles are described in greater detail in the next section.

INSTRUCTIONAL MATERIALS

Development Philosophy

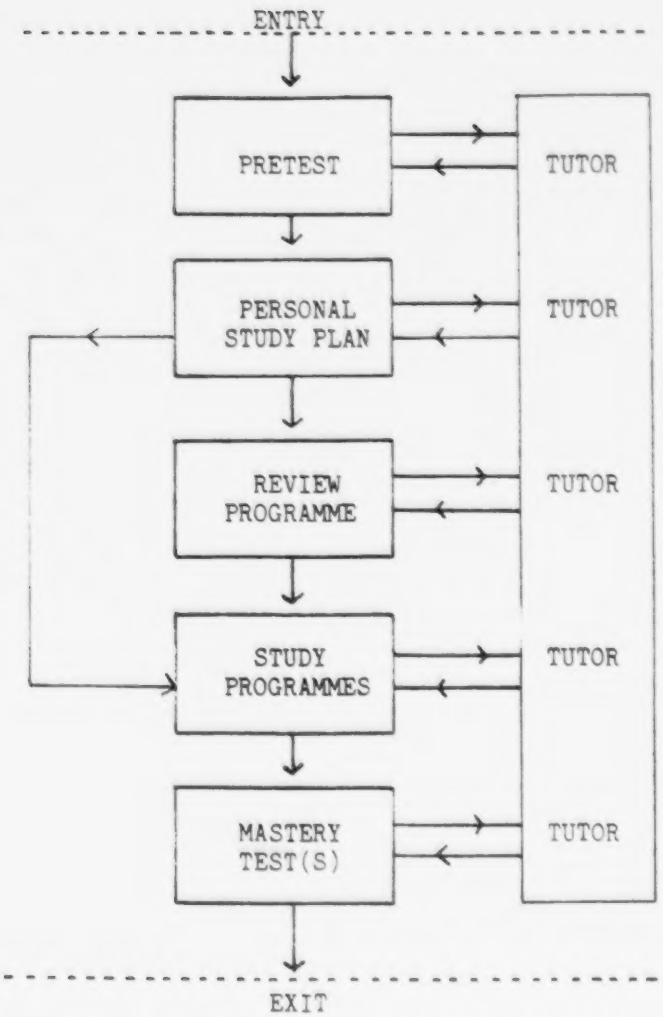
From the many consultations with Aboriginal educational researchers, teachers, advisors, counsellors and administrators, as well as from the literature review, the following set of educational principles appropriate to the learning needs of the prospective target students was established.

- A policy of bicultural education operated to ensure that students were provided with the means for establishing and/or maintaining a sense of their own Aboriginal identity, an appreciation of their Aboriginal cultural heritage and an awareness of Aboriginal current affairs.

- The program provided a focus on studying for a career or vocation rather than on subject areas alone and thereby provided longer-term goal orientation.

Figure 2

Learning Management System



- The program provided for students a transition, or orientation, towards the general educational and sociocultural environment of a higher education institution.

- The program provided appropriate personal support services, bearing in mind that 'affective factors' in some cases can be singularly responsible for determining academic failure. These support services were well integrated into all aspects of the program as well as existing separately in their own right.

- The program was structured around individual learning needs, with a major emphasis on mastering learning objectives.

- The program had a flexible time structure so that students were enabled to progress according to their own best rates of learning.

- The program fostered self-management skills to the extent that students largely assumed a sense of responsibility for their own progress in respect of achieving short-term program goals.

- The program provided regular, comprehensive diagnostic feedback to both students and their tutors.

- The program provided regular consultations for individual students with their own tutor in order that progress was reviewed and that short-term, realistic learning goals were established.

- The program fostered peer-group support amongst the students, rather than isolating them within a totally individualized learning system.

- The program facilitated the development of learning skills appropriate to the needs of undergraduate students, with particular emphasis on the development of high-level cognitive skills such as creative problem-solving, rather than an emphasis on lower-level skills such as short-term memory recall of algorithms.

- Careful selection of staff involved in the program was made on the basis of their academic skills, personal qualities and potential to be trained successfully in accordance with the educational principles listed above.

These educational principles served as guidelines for the construction of an appropriate learning environment, including not only the mathematics and chemistry materials, but also the personal support system. This comprised the working relationship between the tutors and the students, the support subjects (study skills, Aboriginal studies, written and oral English) and the support services (counselling, common room, welfare).

EVALUATION OF THE PROGRAM

The evaluation was largely formative, in that it assisted the project team to modify and improve the program materials and to adjust the support system to meet the personal needs of individual students better.

The effectiveness of the program materials cannot be separated logically from the effectiveness of the support system which facilitated their implementation. However, the evaluation of the program materials focussed on their effectiveness in providing the students with a learning management system and on their content integrity, while the evaluation of the support system focussed on the effectiveness of the personal support

provided to each student by the tutors. Both quantitative and qualitative techniques were used to obtain evaluative information about the program materials and the support system. Full details appear in the Final Report on the project (Malone, Treagust, Fraser & Taylor, 1987). A brief summary of the results of the evaluation appears below.

(a) Program Materials

The effectiveness of the program materials in meeting the learning needs of 'second-chance' Aboriginal students in the areas of chemistry/mathematics was found to depend on a number of factors. The most important of these was the educational background of the student. The unit pretests effectively 'screened' students who were not ready for the study programs and who needed to complete a review program first. However, the review programs were designed not to provide basic instruction in the content area, but to cater for students with some background knowledge and skills in the content area. In this sense, they provided a review of content that had been encountered previously. The mastery tests were designed to measure achievement comparable to that expected at the end of secondary school. Although the structure of the programs requires a non-traditional approach to both teaching and learning, it was demonstrated clearly here that students can be trained in the required study skills. It also was demonstrated that students who developed these study skills were capable of becoming 'independent' learners who adopt a sense of responsibility for managing their own learning.

(b) Support System

The chemistry and mathematics tutors felt able to attend to the learning needs of individual students because of the individualized nature of the programs which freed them from the traditional role of primary source of instruction. During this time, the tutors interacted with students to provide instructional and organizational assistance on an individual basis. The tutors were able to monitor students' personal circumstances, their attitudes and their expressed priorities and prospects by means of personal communications and by the use of an instrument (Fraser, Treagust & Dennis, 1986) that measured students' perceptions of various aspects of the learning environment. Tutors also could undertake self-evaluation using the same instrument and subsequently make alterations to selected components of the learning environment. Of the students who were initially enrolled in the programs, those who completed the course demonstrated increased self-confidence as learners over the year. This was evidenced by the students' self-management skills, a willingness to engage the tutor in debate over misconceptions (sometimes the tutor's), self-evaluation skills and self-motivation to study. By contrast, those students who did not complete the bridging programs largely failed to develop these attributes.

CURRENT STATUS OF THE PROGRAM

The Centre for Aboroginal Studies at WAIT (now Curtin University) now has assumed full responsibility for teaching the mathematics and chemistry bridging programs as part of an expanded Aboriginal Bridging Course for 1987. There are currently six Aboriginal students with suitable educational backgrounds enrolled in the mathematics and chemistry programs. Two of these students are female.

The ability to prepare Aborigines adequately for undergraduate science-and technology-related courses through use of the bridging programs already has been recognized by other tertiary institutions. One of the Aboriginal students who was enrolled in the mathematics and chemistry programs throughout the trialling and evaluation phase (1986) has been accepted into a medical course at the University of Newcastle in New South Wales. The administration of the University of Newcastle altered its entrance regulations in order to recognize the mathematics and chemistry bridging programs as providing appropriate standards of alternative preparation for prospective students. (School-leavers usually are selected from the pool of students whose public examination scores at the Grade 12 level are in the top 10%). Even so, this student from the bridging program had to undergo a week-long selection process in competition with another nine short-listed mature-aged candidates for one of only four places available to 'special-entry' Aboriginal students. It would seem that the support system of the Aboriginal Bridging Course, with its emphasis on personal development, provided benefits for this Aboriginal student. The support system not only operated in a formal way by means of organized 'subjects' for study (e.g., communications and assertiveness training), but it also permeated the 'major' subjects in an informal way bringing students and tutors into regular and close contact with one another.

The mathematics and chemistry programs also have received a favourable response from other Australian universities. Murdoch University in Western Australia recently has established two 'special-entry' places in Veterinary Science for Aborigines who have completed these bridging programs successfully. A Western Australian consortium of users of the Aboriginal Bridging Course has been proposed amongst the three universities based in Western Australia. This consortium would avoid costly duplication of similar courses on neighbouring campuses and would provide Aborigines with a recognized alternative means of gaining access to undergraduate science-and technology-related courses.

The recognition of these bridging programs by other tertiary institutions is to be expected as these institutions encounter the problems of implementing the principles of participation and equity policies and find themselves beset with a lack of resources and inappropriate entry requirements. That this recognition of the ability of the bridging programs to prepare Aborigines for tertiary science courses has come so soon is, perhaps, a measure of the timeliness of this innovative curriculum development.

THE FUTURE OF THE PROGRAM

The nature of these bridging programs is such that they have a broader application outside of the present client group (i.e., Aboriginal 'second-chance' students). Prospective clients of these programs include anyone, whether Aboriginal or not, who wishes to gain access to tertiary science-and technology-related courses and who currently has an inadequate secondary-level education. Those seeking 'special-entry' to tertiary institutions as mature-age candidates are the most appropriate prospective students for a course based on these programs. Such second-chance client groups, including women, migrants and those from low socioeconomic backgrounds, are already the subject of the Federal Government's Participation and Equity programs in other subject areas.

What is needed now is a concerted effort by the Commonwealth Tertiary Education Commission (the national body which has a coordinating

responsibility for all higher education in Australia) to support the 'marketing' of these programs through an active dissemination process. The programs are more than a repackaging of established subject matter - they provide an innovative and highly effective pedagogy. Already, their alternative assessment mechanisms (i.e., 'mastery' learning) have prompted other higher education institutions in Western Australia to contemplate their own long-established assessment criteria and to consider a different paradigm of assessment.

By supporting this project into its dissemination phase, the Commonwealth Tertiary Education Commission has provided the opportunity for higher education institutions to debate higher education entrance practices, access for disadvantaged groups and the principles of participation and equity, all within the context of science-and technology-related courses at the higher education level.

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